Blockchain-Based Solution to Prevent Plastic Pipes Fraud*

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Abstract— Use of counterfeit plastic pipes has caused considerable financial damage to the states and companies. This article proposes a blockchain-based supply chain management system for its market. It can make pipes' use and life cycles transparent, thus guarantee the invariability of pipes mass produced and used. The article provides a high-level technical description, containing ERP-blockchain connection and application for project-specific labels printing, mobile applications for manufactures and pipes installers.

I. Introduction

Blockchain technology appeared as the building block of cryptocurrencies [1]. Nowadays, in parallel to public blockchains, we observe the growth of private blockchains [2], [3], [4]. The most media projects like Libra [5] and TON [6], [7] face regulation problems because of build-in token logic [8]. While classic private or consortium blockchain frameworks like Hyperledger Fabric [9] and Exonum [10] provided solutions for the projects at the state and global business levels [11], [12], [13], [14], including supply chain management applications (SCM) [15], [16], [17], [18], [19], [20]. SCM blockchain allows formalizing relationships between supply chain members mathematically, securing the required level of privacy and providing transparency and auditability.

The blockchain-based supply chain for plastic pipes is considered in the paper. The system was implemented and launched in test mode [21] by the largest Russian manufacturer of plastic pipes–Polyplastic Group [22]. In the paper, we provide the problem overview and high-level technical description of the proposed solution. The rest of the paper is organized as follows. The plastic pipes market participants and the problem of pipes falsification are listed in Section II. A high-level technical description of the proposed blockchain solution is introduced in Section III. The obtained results are discussed in Section IV.

II. Russian Plastic Pipes Market

A. Counterfeit and Falsification

The fight against low-quality products is a relevant task in all sectors of the economy. In different countries, the issue is solved in different ways: a strict state's regulatory policy works for some countries, a combined approach that merges fundamentally new innovative technologies and the involvement of public services to monitor and control producers of goods works for others.

Fig. 1. Plastic pipe with a label (in Russian)

In Russia, in several industries, the issue of combating counterfeit products is so acute that it led to the unification of manufacturers of quality products into industry associations that centrally take practical steps to identify and suppress the activities of organizations producing low-quality products. A striking example is the Pipe Systems Manufacturers Association (PSMA) [23], which considers the fight against manufacturers of counterfeit and counterfeit products as one of its top priorities.

According to PSMA estimates, the share of counterfeit products in the polyethylene pipe market is 30% of the total volume, which amounts to 9 billion rubles per year (approximately 145 million USD) [24].

Recently, PSMA and Polyplastic Group–the leading producer of polymer pipes in Commonwealth of Independent States (CIS) [22]–initiated the development of a scenario for using modern information technologies to combat the situation with falsification and counterfeit products on the market. For industry experts, it is evident that one of the critical components of the struggle should be the labelling of pipe products and the possibility of organizing product traceability until it is no longer in circulation. But the question arose of how to ensure what unscrupulous manufacturers are most afraid of–the absolute transparency of processes and the invariance of all data for all industry representatives,

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including government agencies?

B. Participants

At the moment, the polymer pipe market consists of the following participants.

- **Pipe raw materials manufacturers.** This article describes a solution for which integration with manufacturers of raw materials is not required. The PSMA performs some functions of the manufacturers of the raw materials in the system. In the future, it will be possible to connect raw materials manufacturers into the solution, but this is not required at the stage of concept verification.
- **Plastic pipe manufacturers.**
- **Association of Pipeline System Manufacturers (PSMA).**
- **Distributors.** This article discusses a solution for which integration with distributors is not required. Distributors have no motivation to join the system on a voluntary basis. But in the future, the solution can be improved by distributors' inclusion.
- **Pipe users.** For example, water supply and heat networks, construction companies.
- **Installers.**
- **Supervisory authorities/regulators.**

C. Key System Requirements

The system should unite the interests of all market participants in their joint work, create the basis for effective counteraction to the production of counterfeit products, thanks to reliable, timely and secure information in all its diversity, giving all participants a unified operational picture of processes in the pipe market.

The system should provide trust from partners by fulfilling the following properties

- Inability to enter inconsistent information.
- Presence of mechanisms for the coordination of changes by all partners in real-time.
- Inability to change data retroactively.
- Independent access to the necessary data for each partner. That is, the necessary data should be stored with each partner.
- Presence of a data synchronization algorithm between partners in real-time.
- The system must guarantee compliance with access rights to information.

Centralized databases do not fulfil the requirements, while blockchain technology exactly meets the key requirements for the system.

III. PROPOSED SOLUTION

A. Control Over the Mass of Raw Materials

The strategic goal of creating a solution to the fight against trafficking in polymer pipes is the elimination of falsification from non-pipe secondary raw materials and counterfeiting as a phenomenon.

The number of producers of pipe raw materials is limited: in Russia, in 2018 there were two certified producers, and another producer is planned to appear in 2020. Counterfeit products are made from non-pipe or secondary raw materials. The mass of manufactured raw materials does not correspond to the mass of manufactured pipe products.

In order to identify unscrupulous manufacturers, it is necessary to compare the mass of pipe raw materials and products manufactured by them, taking into account the product formulation (see Figure 4). At the moment, the data necessary for comparison are stored separately from market participants. Combining data in a centralized repository has a key flaw: it is imperative that all participants trust the repository owner.

B. Plastic Pipes Market

Information about raw materials and produced pipes comes from Enterprise Resource Planning (ERP) systems of pipes manufacturers. Dishonest manufacturers are able to transmit the wrong data and keep double-entry bookkeeping. To eliminate the possibility of double-entry accounting, pipes will be labelled by QR code which contains a unique identifier and special information for each pipe.

Information about scanning the QR code will be stored in a distributed ledger, which will allow tracking each pipe at all stages of the life cycle.

C. Role Model

Organizations can register in the system in four roles

- system administrator
- pipe manufacturer
- consumers
- raw material manufacturer.

To register in the system, a user with the administrator role must agree to join the organization in this role. A user with the administrator role can also disconnect a legal entity from the system. It is assumed that at the MVP stage, the PSMA will act as the administrator. At the industrial decision stage, the administrator will be the Ministry of Industry and Trade.

Legal entities can register their employees in the system and empower them as

- administrator
- labels printer
- product shipment
- product reception
- label blanking
- full functionality.

D. System description

The general data workflow is represented in Figure 2. The proposed solution technically consists of

- Private blockchain on the top of existing ERP-system to timestamp all the operations and ensure transparent, immutable, and cryptographically verifiable action log [25]. The Exonum framework [10] is used for the implementation. See Figure 3 for blockchain endpoints.
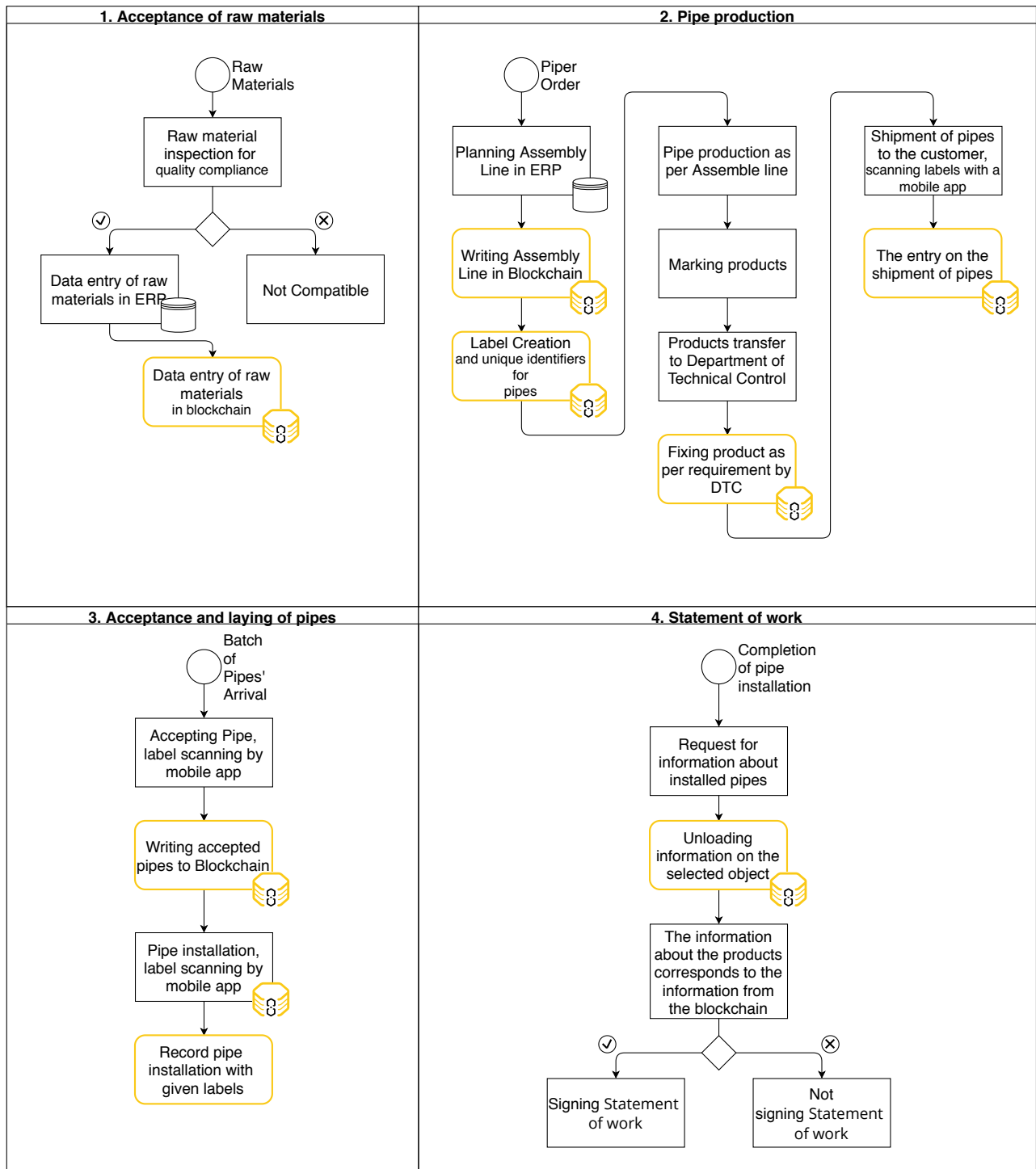
1. Acceptance of raw materials

Raw Materials

Raw material inspection for quality compliance

Data entry of raw materials in ERP

Not Compatible

Data entry of raw materials in blockchain

2. Pipe production

Piper Order

Planning Assembly Line in ERP

Writing Assembly Line in Blockchain

Label Creation and unique identifiers for pipes

Pipe production as per Assemble line

Marking products

Products transfer to Department of Technical Control

Fixing product as per requirement by DTC

Shipment of pipes to the customer, scanning labels with a mobile app

The entry on the shipment of pipes

3. Acceptance and laying of pipes

Batch of Pipes' Arrival

Accepting Pipe, label scanning by mobile app

Writing accepted pipes to Blockchain

Pipe installation, label scanning by mobile app

Record pipe installation with given labels

4. Statement of work

Completion of pipe installation

Request for information about installed pipes

Unloading information on the selected object

The information about the products corresponds to the information from the blockchain

Signing Statement of work

Not signing Statement of work

Fig. 2. Data flows in the pipe production process

- Application for the for project-specific labels printing. Examples of printed labels and labels on pipes are presented in Figures 5 and 1. Bulk QR-codes are used for better recognition from the cylindrical surface by smartphones.
- Mobile applications for distributors (see Figure 6) and pipes installers (see Figure 7).

IV. CONCLUSION

The paper introduces a blockchain-based supply chain approach to prevent plastic pipes falsification. The system was implemented and launched in test mode by the largest Russian manufacturer of plastic pipes [21].

Benefits of implementing solutions for main market participants are
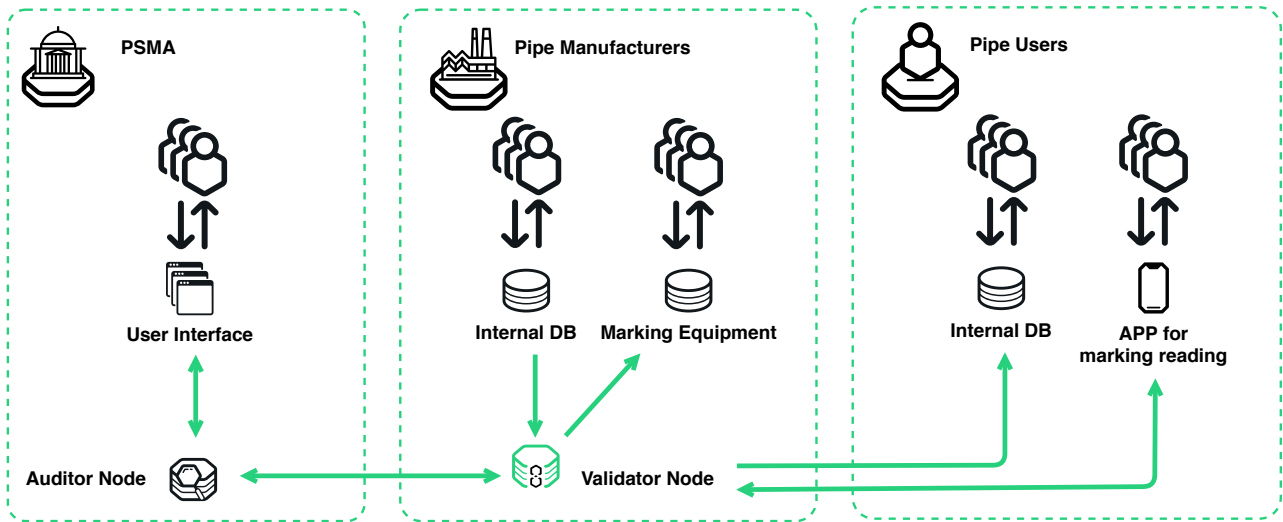
- Raw materials manufacturers

Fig. 3.   Blockchain network structure

Fig. 4.   Material control tab in the proposed system (artificial data, in Russian)
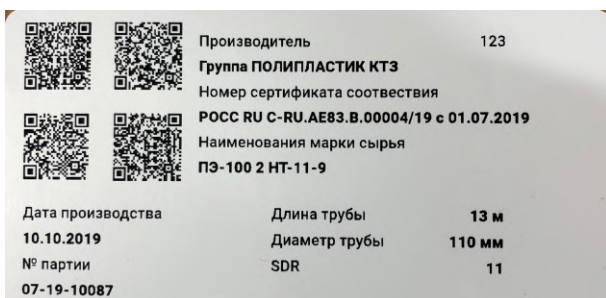

Fig. 5.   Printed pipe label (in Russian)

- – accounting and control of supply channels and scope of shipped raw materials
- – increasing sales of raw materials with higher added value by reducing the use of base grades for other purposes
- – monitoring the correspondence of the amount of shipped raw materials to the number of products released from this raw.

- Pipe manufacturers

  - – increasing sales profitability by reducing unfair competition
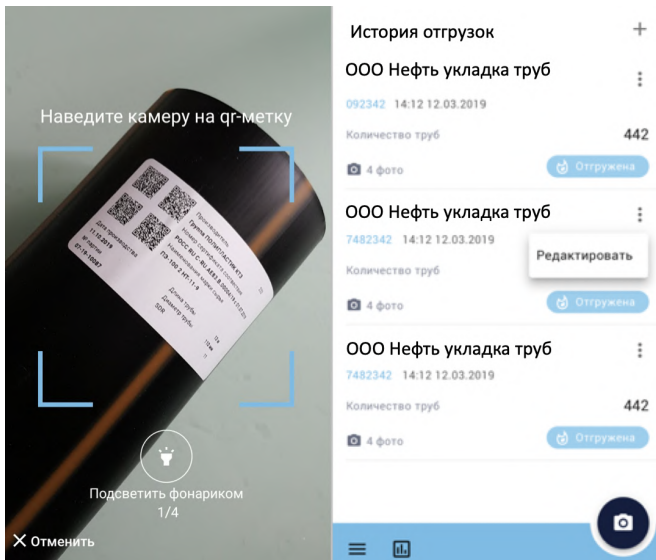 - – increasing confidence in polyethylene pipes

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Fig. 6. Scan Qr code (left) and shipment history (right) tabs in the mobile application for distributors (artificial data, in Russian)
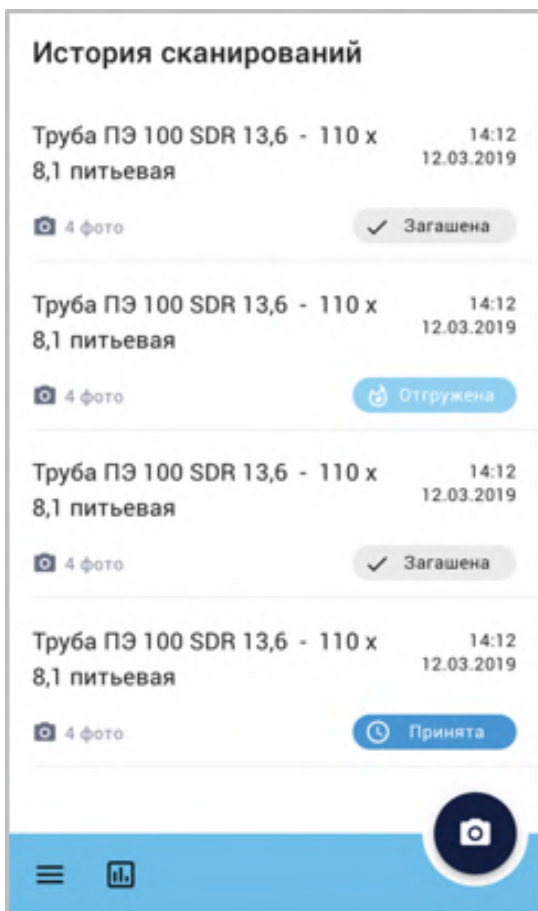

Fig. 7. Label scan history in the application for pipe installers (artificial data, in Russian)

– obtaining reliable data on the situation in the industry, which can be used as arguments in defending the interests of the industry.

- Pipe users
  - the use of quality pipe products
  - savings by reducing accident costs
  - reducing the risk of accidents and holding liable for emergency situations.

Supervisory authorities can get reliable information from the system, which results in online auditablility and industry transparency. And once they adopt corresponding regulatory rules, distributors and pipe users will be able to follow them at almost zero additional costs.

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